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Applying Feature-Based Product Line Engineering in Unclassified and Classified Environments

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Business Architecture

- Current state:
  - Expensive / inefficient duplication of technology environments
  - Difficult to leverage company's global staff & those awaiting access to classified content
  - Transfer of files between environments manual = prone to human error, costly, slow
  - Rarely exportable for global market

- Future state:
  - Efficient, consolidated virtual product line engineering (PLE) Factory for an entire product family
  - Easily leverage company's global staff & those awaiting access to classified environments
  - Cybersecurity protects confidentiality and integrity during automated transfer of files between security zones
  - Readily exportable for global market – business rules enforce export/import law compliance

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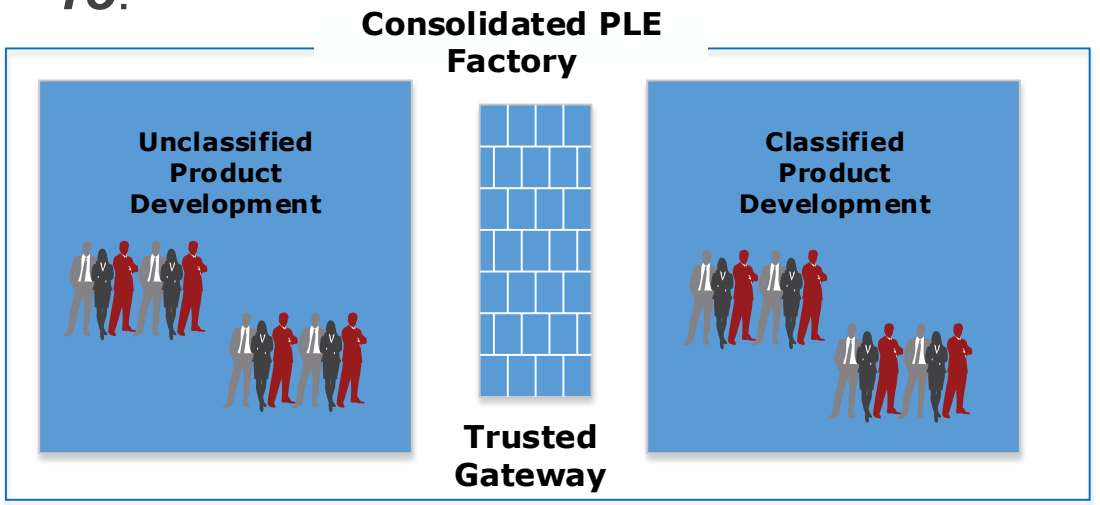
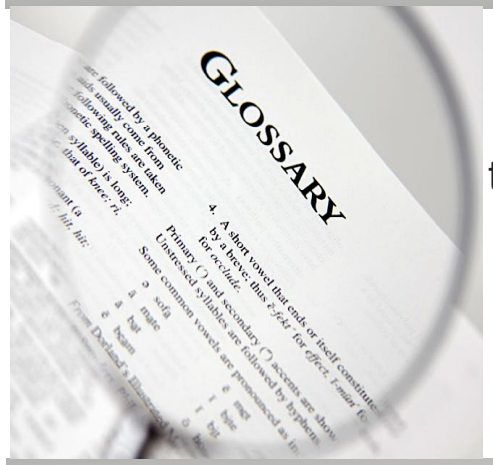


Product Line and Product Line Engineering Defined

Product Line Engineering International Working Group

Submitted 1st Qtr 2019: ISO/IEC 26580, Methods and Tools for the Feature-Based Approach to Systems and Software Product Line Engineering (FBPLE)

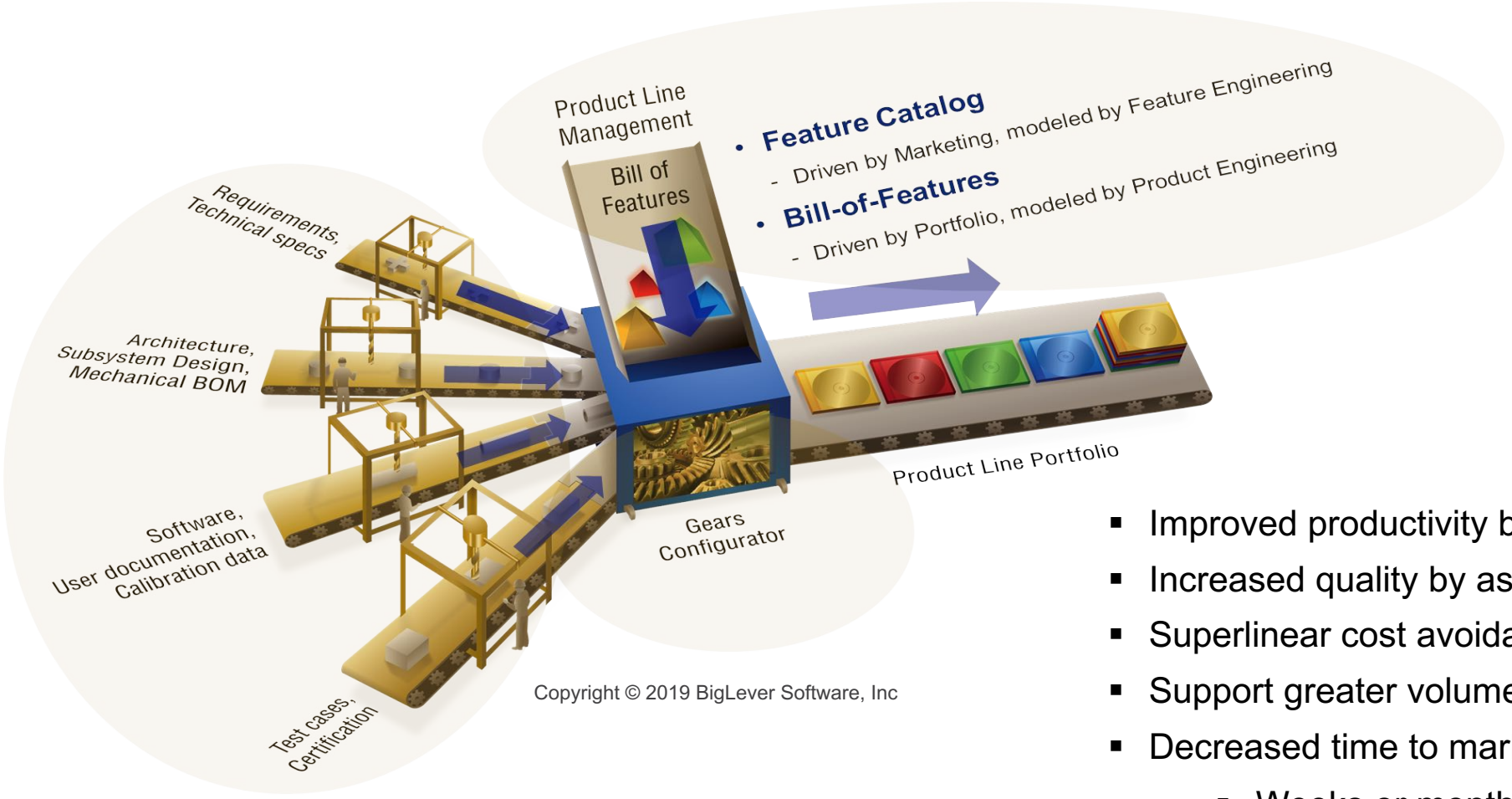
Product Line:
a family of similar products or systems with variations in features and functions



Product Line Engineering:
the engineering of a product line using a *shared set of engineering assets*, a *managed set of features*, and an *automated means of production*…

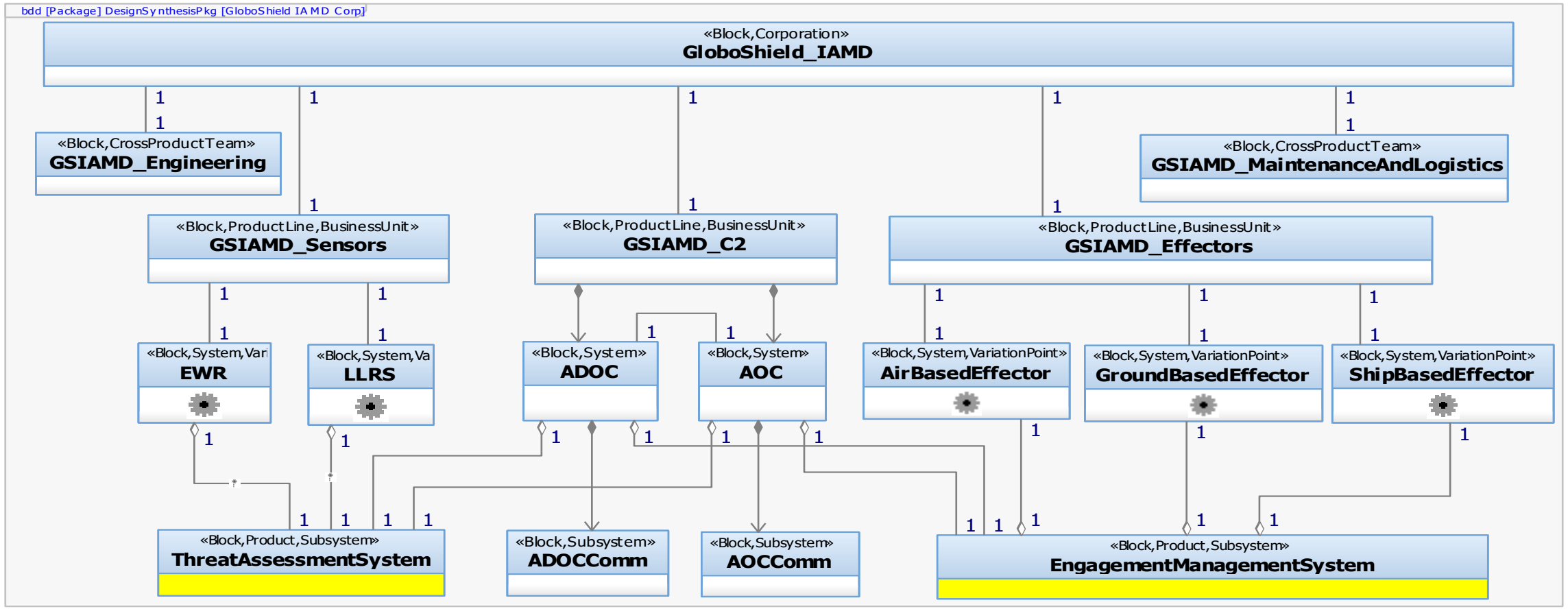
- taking advantage of the **commonality** shared across the family
- efficiently and systematically managing the **variation** among the systems

FBPLE Embraces a Factory Paradigm



- Improved productivity by as much as 10x
- Increased quality by as much as 10x
- Superlinear cost avoidance
- Support greater volume of work with same staff
- Decreased time to market (to field, to launch)
  - Weeks or months, not years

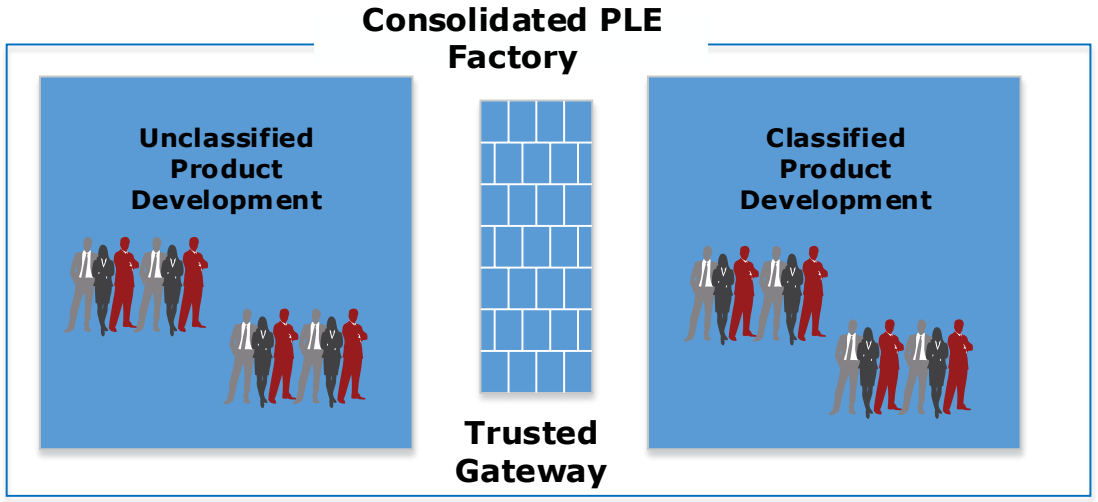
Fictional GloboShield Product Line Architecture



- Variation points denoted by gear symbol
  - For example effectors can vary for each delivered product instance

Relevant Concepts

Security Zones
- Information system segments with -
- Rules-driven control of inbound and outbound traffic that -
- Establish a perimeter within which sensitive or classified information is processed

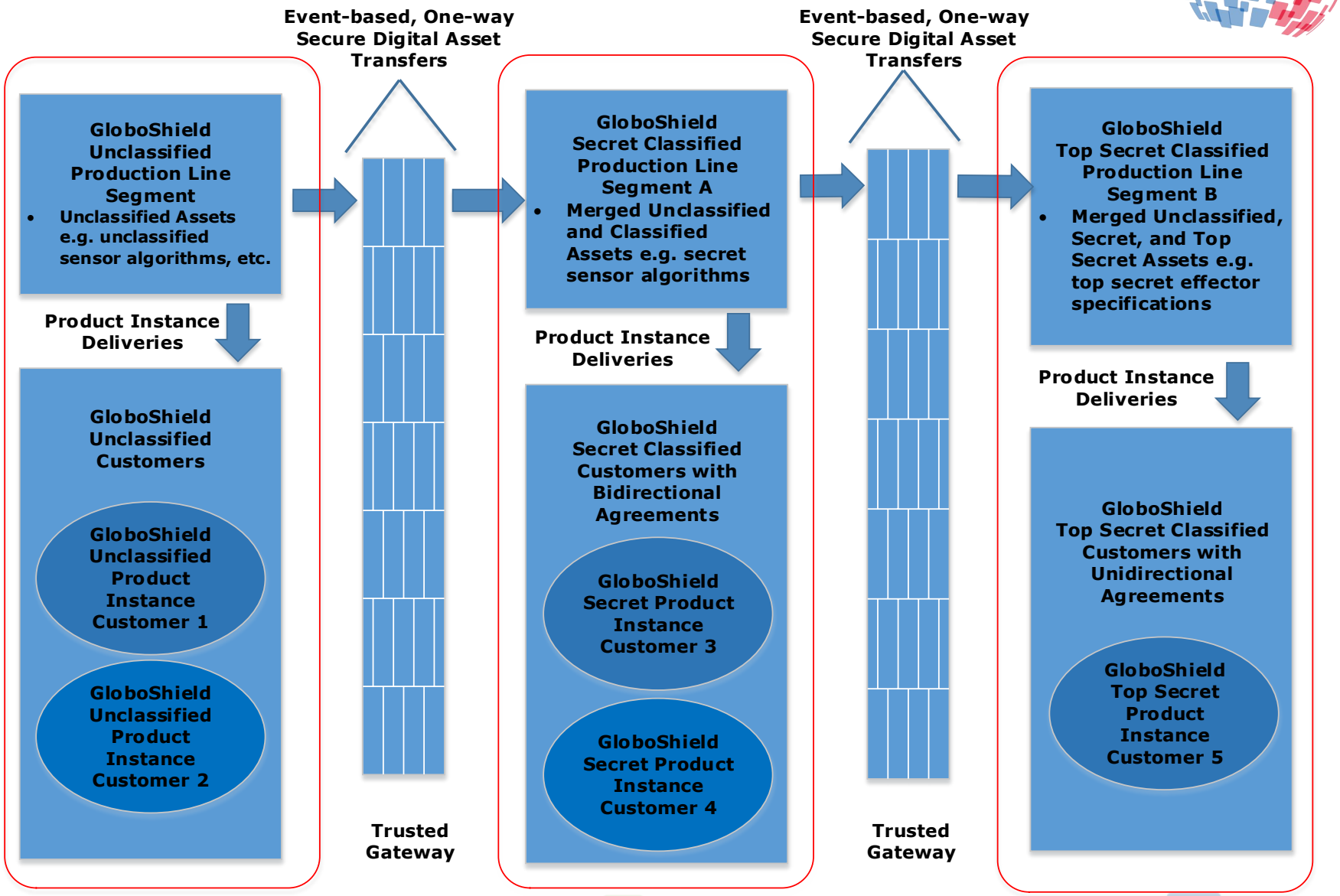


Trusted Gateway
- Provides secure, automated file transfers with -
- Rules-driven deep inspection of file contents and meta-data such that it -
- Transfers only those files allowed by security policies

Cybersecurity Controls
- Safeguards and/or countermeasures that -
- Protect confidentiality, integrity, availability, and more

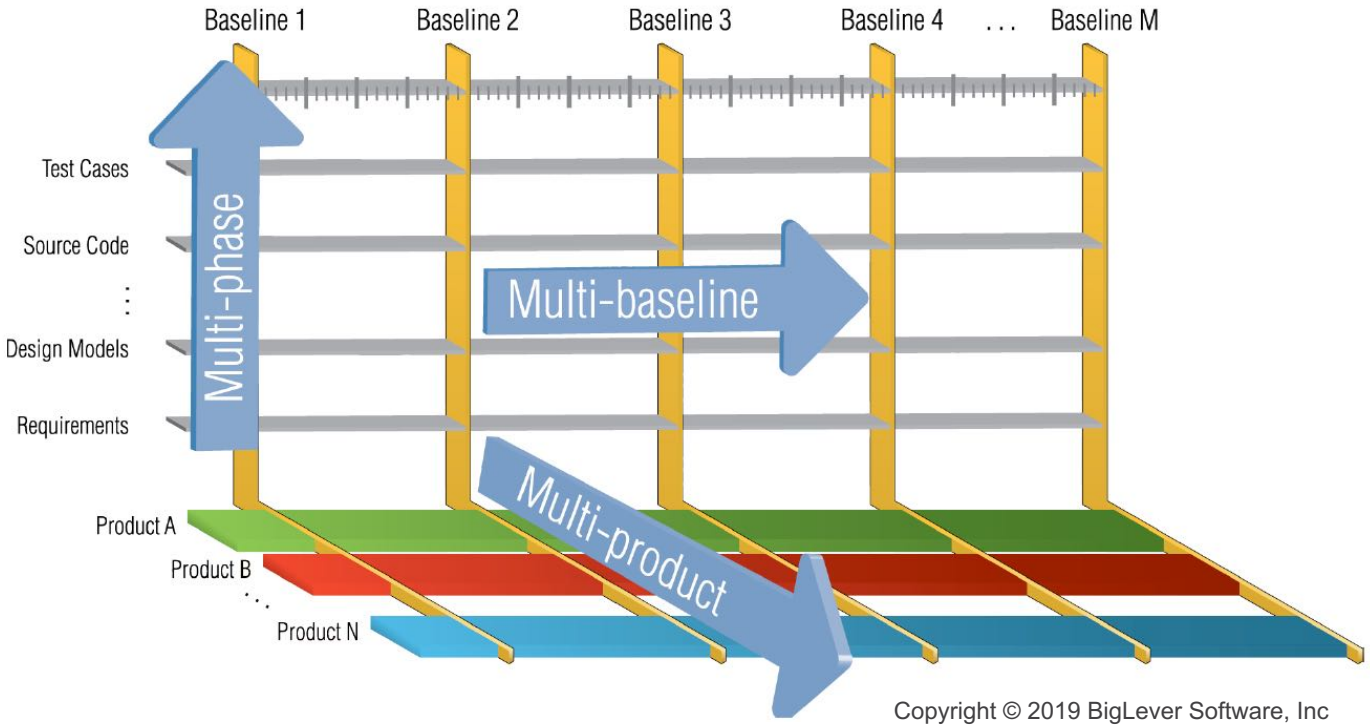
Example Production Scenario: Mixed Data Sharing Agreements

- Daisy chain production line segments for unclassified, secret and top secret classified product instances



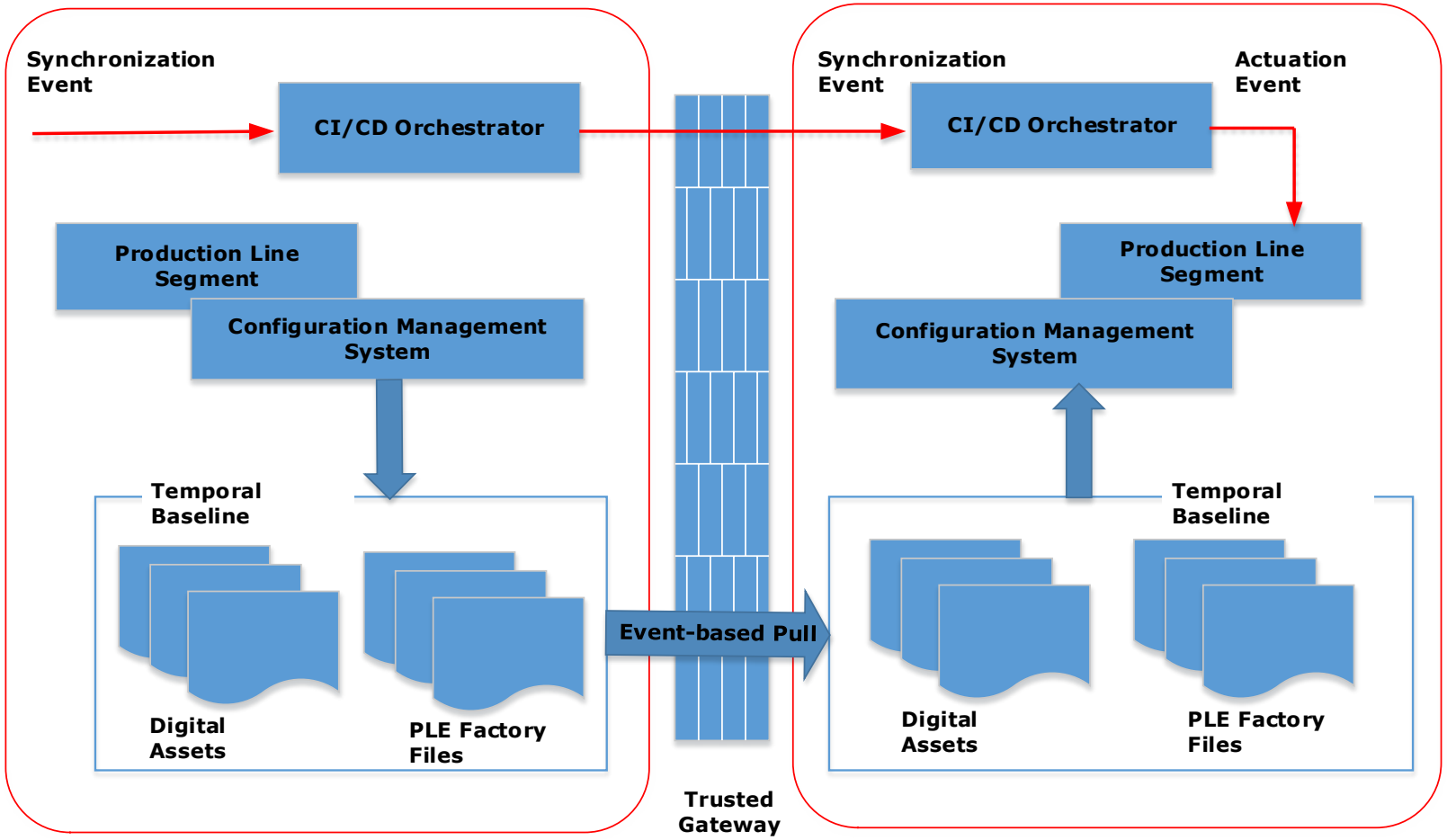
Product Line Change Management

- Multiple axis problem:
  - Managing the life cycle of each product (vertical axis)
  - Evolving the portfolio over time (horizontal axis)
  - Managing the plurality of products (outward-pointing axis)
- Evolution in a multiple security zone context brings an additional complexity:
  - Change happens simultaneously in each of the different information system security zones & production line segments
  - Versions of digital assets & generated product instances must be coordinated over time per the team's operating rhythm and customer delivery cycles to produce a consistent whole without compromising cybersecurity protocols



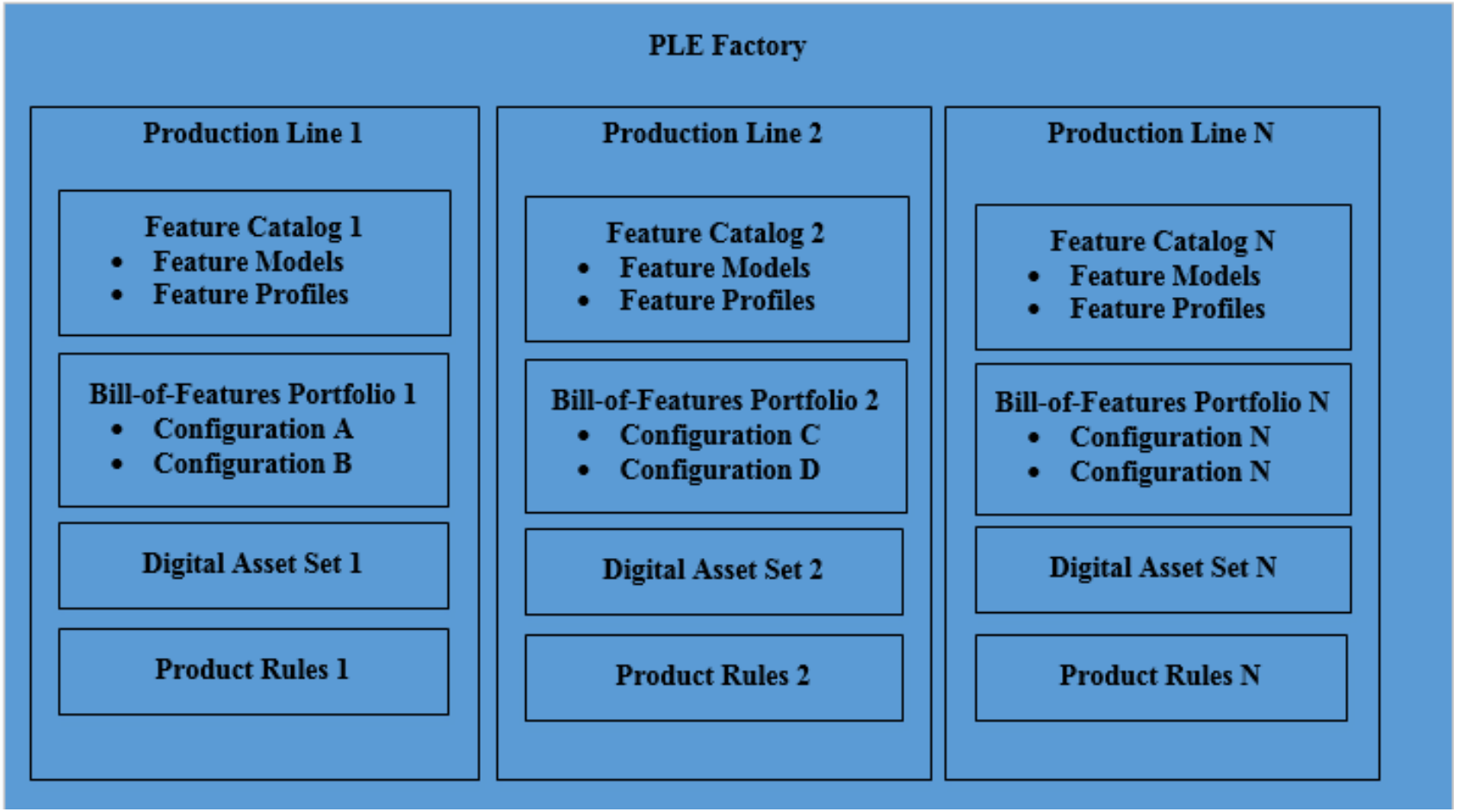
PLE Factory Temporal Baseline Management

- File baseline management over time
- Production-line-segment-level baseline
  - Digital asset files
  - PLE Factory files
- Continuous Integration / Continuous Delivery (CI/CD) orchestrator synchronization events trigger automated pull and merge of discrete files via trusted gateway
  - Production team operating rhythm
    - New Features
    - Bug fixes
  - Individual customer delivery cycle
- Orchestrator actuation events trigger automated production line segment actuation (run)



PLE Factory Concepts

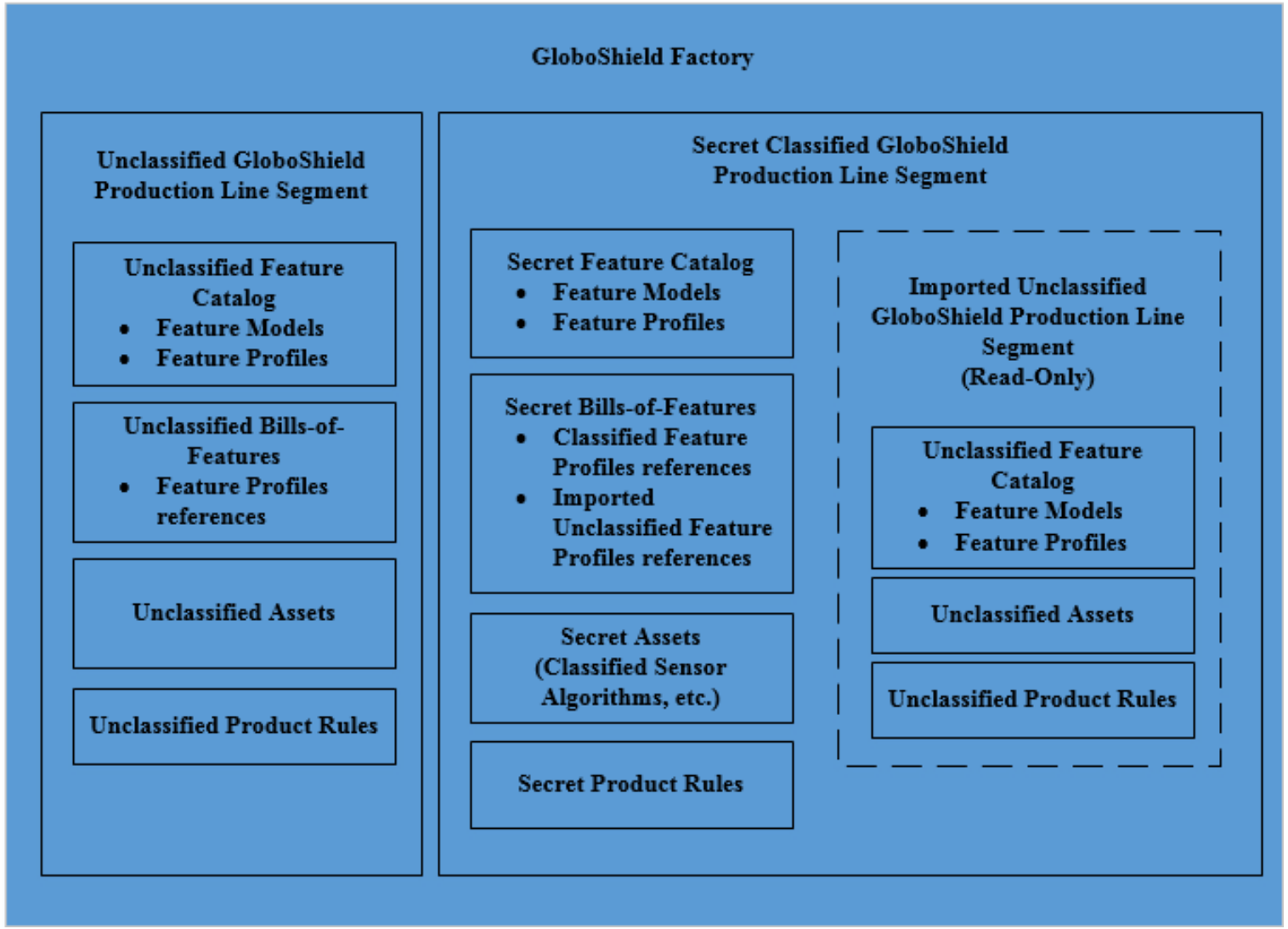
- PLE Factory
  - Set of production line segments a.k.a. subassembly lines
- Feature Catalog
  - Feature Models
  - Feature Profiles
- Bill-of-Features Portfolio
  - Configuration Specifications
- Shared Digital Assets
- Product Rules



Derived from Krueger, C and Clements, P (2017), 'A Feature Ontology to Support Feature-Based Product Line Engineering', *Proceedings of the 27th Annual INCOSE International Symposium*, Adelaide, Australia

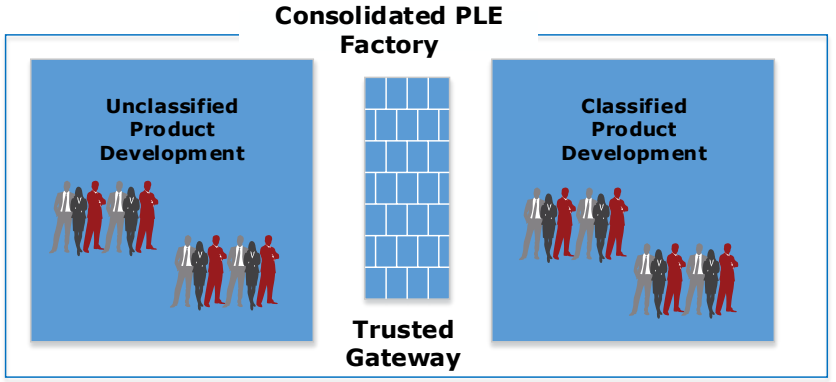
GloboShield Production Line Modular Design

- Daisy chained subassembly lines merge read-only copies of upstream factory components
- Can selectively choose content to merge across the daisy chains



Summary

- Application of Feature-Based Product Line Engineering (FBPLE) results in significant improvements in system quality, time to market / time to field, continuous delivery of user value, and more
- Historically unclassified and classified product development is performed in separate information systems by separate teams with (semi-)manual implementation of key security controls e.g., to transfer files between security zones
  - Expensive, slow time to field features (years), prone to human error
- Efficient, consolidated PLE Factory for an entire product family as architected realizes FBPLE benefits while protecting the confidentiality, integrity, and availability of the development system and subsequently the fielded system
  - Daisy chain of sub-assembly lines with trusted gateways and continuous integration, continuous delivery (CI/CD) tooling
- Easily leverage company's global staff & those awaiting access to classified environments
- Readily exportable for global market – product rules automatically enforce export/import law compliance



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Biography

James Teaff, M.E. wrote his first line of code as a professional in the early 80's while working for a tech startup. Subsequently over the past several decades he has worked for numerous aerospace and defense companies across the full system development lifecycle, from principal investigator and proposal writer to IPT lead, chief architect, requirements analyst, Scrum Master, programmer, tester, 2nd tier O&M support, and more. James holds a Master of Engineering in Engineering Management from the University of Colorado, and a Bachelor of Science degree in Computer Science from Colorado State University. He is an INCOSE Certified Systems Engineering Professional (CSEP), and is an active member of the INCOSE International Product Line Working Group.

Dr. Bobbi Young is an engineering fellow and certified architect at Raytheon. She currently leads an Internal Research and Development Project focusing on adoption of PLE across the business. She is regarded throughout Raytheon as an expert in MBSE and co-chairs an MBSE Technical Interchange Group. Bobbi is also a faculty member of Worcester Polytechnic Institute as an MBSE instructor and has co-authored a book on object oriented analysis and design. She is a US Navy Commander (ret).

Dr. Paul Clements is the Vice President of Customer Success at BigLever Software, Inc., where he works to spread the adoption of systems and software product line engineering. Prior to this, he was a senior member of the technical staff at Carnegie Mellon University's Software Engineering Institute, where for 17 years he worked leading or co-leading projects in software product line engineering and software architecture documentation and analysis. Prior to the SEI, Paul was a computer scientist with the U.S. Naval Research Laboratory in Washington, D. C.